REMARKS/ARGUMENTS

Claims 1-75 were previously pending in the application. Claims 8, 38, and 59 are amended; and new claims 76-78 are added herein. Assuming the entry of this amendment, claims 1-78 are now pending in the application. The Applicant hereby requests further examination and reconsideration of the application in view of the foregoing amendments and these remarks.

In paragraph 2 of the office action, the Examiner stated, on page 2, that "Claims 1, 12-24, 27, 28, 31, 42-53 and 63-75 are rejected under 35 U.S.C. 102(b) as being anticipated by Moorer." In the very next paragraph on page 2, the Examiner referred to "claims 1, 12-14, 24, 27-31, 42-45, 47-50, 69 and 70." The Applicant requests clarification as to whether or not claims 29-30 are rejected under 35 U.S.C. 102(b) as being anticipated by Moorer.

In paragraph 5, the Examiner rejected claims 2-9, 25-26, 32-39, and 54-60 under 35 U.S.C. 103(a) as being unpatentable over Moorer in view of Elko. In paragraph 6, the Examiner rejected claims 10-11, 40-41, and 61-62 under 35 U.S.C. 103(a) as being unpatentable over Moorer in view of Elko, and further in view of Staple.

For the following reasons, the Applicant submits that all of the now-pending claims are allowable over the cited references.

Claims 1, 31, and 51

Claim 1 is directed to a method for processing audio signals. According to claim 1, a plurality of audio signals are received, each audio signal having been generated by a different sensor of a microphone array. The plurality of audio signals is decomposed into a plurality of eigenbeam outputs, wherein each eigenbeam output corresponds to a different eigenbeam for the microphone array and at least one of the eigenbeams has an order of two or greater.

In rejecting claim 1, the Examiner stated that Moorer discloses "decomposing the plurality of audio signals into a plurality of eigenbeam outputs ..., wherein each eigenbeam output corresponds to a different eigenbeam for the microphone array and at least one of the eigenbeams has an order of two or greater," citing the end of Moorer's column 5. For the following reasons, the Applicant submits that the Examiner misinterpreted the teachings in Moorer in rejecting claim 1.

Moorer discloses a technique for processing a set of input audio signals in order to generate a desired sound field using a specified configuration of speakers. The technique is illustrated in Figs. 3 and 4. Fig. 3 illustrates the recording portion of the Moorer's overall technique, while Fig. 4 illustrates the playback portion of the overall technique.

In particular, Fig. 3 shows two monaural sources 17 and 19, where each monaural source corresponds to a single audio signal. See, e.g., column 4, lines 30-37. As shown in Fig. 3, the two audio signals are mixed in different combinations (based on a specific five-speaker configuration) to form five recorded signals S1-S5 (see, e.g., column 4, lines 41-60), which are then stored or transmitted for playback using the processing illustrated in Fig. 4. See, e.g., column 6, lines 44-46. According to column 4, lines 37-38, in practice, there are usually far more than two input signals used to make a recording.

Significantly, however, the number of recorded signals (i.e., five in the example of Fig. 3) is a function of the number of speakers in the specific speaker configuration used to generate the recorded signals. See, e.g., column 4, lines 29-30 ("Each of these signals is to drive an individual loud speaker.") Thus, no matter how many input signals are used (i.e., two in the example of Fig. 3 and far more than two

in practice), the number of recorded signals is always equal to the number of speakers in the specific speaker configuration used to generate the recorded signals.

Fig. 4 shows the processing used to convert the recorded signals generated in Fig. 3 into speaker signals to be applied to individual speakers to generate the desired sound field. See, e.g., column7, lines 4-6. This conversion entails two steps: harmonic matrixing 51 and speaker matrixing 53.

In the harmonic matrixing 51 of Fig. 4, the five recorded signals S1-S5 are converted into three spatial harmonic signals: a zero harmonic signal a_0 and two first harmonic signals a_1 and b_1, where the first harmonic signals are orthogonal to each other. See, e.g., column 7, lines 6-10. According to Moorer, harmonic matrixing can be modified such that the five recorded signals S1-S5 can be used to generate spatial harmonics higher than just the zero and first harmonic signals, where two additional orthogonal signals would be generated by matrix 51 for each further harmonic. See, e.g., column 7, lines 11-13.

In the speaker matrixing 53 of Fig. 4, the three spatial harmonic signals a_0, a_1, and b_1 are combined (based on the actual locations of the five speakers to be used to generate the desired sound field) to generate five speaker signals S1'-S5'. See, e.g., column 7, lines 13-28. Note that these actual speaker locations may differ from those of the specific speaker configuration used in Fig. 3 to generate the recorded signals. In fact, this flexibility in speaker location is the primary advantage provided by Moorer's technique.

According to claim 1, a plurality of audio signals generated by a microphone array are decomposed into a plurality of eigenbeam outputs corresponding to different eigenbeams for the microphone array, where at least one of the eigenbeams has an order of two or greater. In Moorer's Figs. 3 and 4, the only things that could be interpreted as constituting a microphone array are the monaural sources 17 and 19. As described above, the two (or in practice more) input signals from these monaural sources are combined to form recorded signals S1-S5. Since there is <u>no</u> teaching in Moorer that recorded signals S1-S5 are eigenbeam outputs, the processing taught in Fig. 3 <u>cannot</u> be said to constitute an example of a decomposition of a plurality of audio signals generated by a microphone array into a plurality of eigenbeam outputs, let alone eigenbeam outputs corresponding to different eigenbeams for a microphone array, where at least one of the eigenbeams has an order of two or greater.

Moorer teaches that harmonic matrix 51 of Fig. 4 converts the recorded signals into harmonic signals and suggests that the harmonic signals may have order greater than one, but Moorer's recorded signals are <u>not</u> audio signals generated by a microphone array. As such, Moorer's harmonic matrix 51 cannot be said to decompose a plurality of audio signals generated by a microphone array into a plurality of eigenbeam outputs, let alone eigenbeam outputs corresponding to different eigenbeams for a microphone array, where at least one of the eigenbeams has an order of two or greater.

In Figs. 7 and 8, Moorer does in fact teach a technique for decomposing a plurality of audio signals generated by a microphone array into a plurality of eigenbeam outputs. Significantly, however, the decomposition of those audio signals is limited to zero and first harmonics only. In particular, Fig. 8 shows a three-microphone array capable of generating three microphone signals m1-m3, and Fig. 7 shows a technique for combining those three microphone signals m1-m3 to generate three harmonic signals: zero harmonic signal a_0 and first harmonic signals a_1 and b_1. See, e.g., column 9, lines 33-52. There is no teaching or even suggestion of extending the decomposition of Figs. 7 and 9 to harmonic orders greater than first order, let alone describing exactly how such a higher-order decomposition could possibly be achieved.

For all these reasons, the Applicant submits that claim 1 is allowable over Moorer. For similar reasons, the Applicant submits that claims 31 and 51 are allowable over Moorer. Since the rest of the

claims depend directly or indirectly from claims 1, 31, or 51, it is further submitted that those claims are also allowable over Moorer.

Claims 6, 36, and 57

According to claim 4, the microphone array comprises the plurality of sensors mounted on an acoustically rigid sphere. According to claim 5, which depends from claim 4, one or more of the sensors are pressure sensors. According to claim 6, which depends from claim 5, at least one pressure sensor comprises a patch sensor operating as a spatial low-pass filter to avoid spatial aliasing resulting from relatively high frequency components in the audio signals.

In rejecting original claim 6, on page 4, the Examiner appears to admit that Moorer does not teach the features of claim 6 and appears instead to rely on Elko, but the Examiner fails to identify any teachings in Elko related to the features explicitly recited in claim 6. In fact, neither Moorer nor Elko teach or even suggest the combination of features covered by claim 6. The Applicant submits that this provides additional reasons for the allowability of claim 6 (and also claims 36 and 57 as well as claims 7-8, 37-38, and 58-59, which depend from claims 6, 36, and 57, respectively) over Moorer and Elko.

Claims 7, 37, and 58

According to claim 7, at least one patch sensor comprises a number of proximally configured, individual pressure sensors, wherein, for each such patch sensor, analog signals generated by the number of individual pressure sensors are combined before sampling to generate a digital audio signal for that patch sensor. Here, too, in rejecting claim 7, the Examiner appears to admit that Moorer does not teach the features of claim 7 and appears instead to rely on Elko, but the Examiner fails to identify any teachings in Elko related to the features explicitly recited in claim 7. The Applicant submits that this provides additional reasons for the allowability of claim 7 (and also claims 37 and 58) over Moorer and Elko.

Claims 8, 38, and 59

According to currently amended claim 8, the at least one pressure sensor further comprises a point sensor used to generate relatively low frequency audio signals, where the patch sensor is used to generate relatively high frequency audio signals. Here, too, in rejecting claim 8, the Examiner appears to admit that Moorer does not teach the features of claim 8 and appears instead to rely on Elko, but the Examiner fails to identify any teachings in Elko related to the features explicitly recited in claim 8. The Applicant submits that this provides additional reasons for the allowability of claim 8 (and also claims 38 and 59) over Moorer and Elko.

Claims 9, 39, and 60

According to claim 4, the microphone array comprises the plurality of sensors mounted on an acoustically rigid sphere. According to claim 9, which depends from claim 4, one or more of the sensors are elevated over the surface of the sphere. One possible embodiment of the subject matter of claim 9 is illustrated in Fig. 26A, which shows a sensor elevated over the surface of the underlying sphere.

In rejecting claim 9, the Examiner admitted that "Moorer fails to show the locations of the microphones being elevated above the surface of the sphere." The Examiner also appears to admit that Elko fails to teach this same feature. Nevertheless, the Examiner argues that "the microphones could be flush mounted on the sphere as taught in Elko, or other ways, such as above the surface to give a better coverage not limited by the flush mounted surface." As such, the Examiner concludes that "it would have

been obvious to one of ordinary skill in the art to modify Moorer and Elko by mounting the microphones above the surface in order to give the microphone a wider coverage."

First of all, the Examiner's reason for modifying the teachings in Moorer and Elko is not even correct. A microphone array consisting of a sufficient number of microphones "flush mounted" on a rigid sphere will provide full 4π steradian coverage. As such, elevating one or more microphones over the surface of the sphere will not and can not provide a wider coverage, because 4π steradian coverage is already the maximum possible coverage. Since the Examiner relied on an incorrect motivation for modifying the teachings in Moorer and Elko, then that modification is improper, and the rejection based on such an improper modification is also improper.

In reality, the Examiner's rejection of claim 9 is based on nothing but classic and improper hindsight reasoning.

As described in the present specification, elevating one or more microphones over the surface provides the advantage of significantly increasing the microphone beamformer output signal-to-noise ratio at lower frequencies without spatial aliasing. Not only do Moorer and Elko not suggest the elevation of one or more microphones over the surface of a sphere, they do not even address the problem of improving signal-to-noise ratio without spatial aliasing.

The Applicant submits that this provides additional reasons for the allowability of claim 9 as well as claims 39 and 60 over the cited references.

<u>Claims 10, 40, and 61</u>

According to claim 10, the microphone array comprises the plurality of sensors mounted on an acoustically soft sphere. As readily understood by those of ordinary skill in the relevant art, the acoustical softness or hardness of a spherical microphone array refers to the acoustic properties of the medium through which the sound travels to the microphone array as compared to the acoustic properties of the material used in making the sphere. An acoustically hard sphere is one in which the impedance to sound propagation through the sphere material is greater than the impedance to sound propagation through the medium outside of the sphere. An example of an acoustically hard sphere is a sphere made of solid metal or plastic, where the medium outside of the sphere is air. An example of an acoustically soft sphere, on the other hand, is a hollow plastic, air-filled sphere, where the medium outside of the sphere is water, in the case of underwater applications. Significantly, the term "acoustically soft" does not refer to the <u>mechanical</u> softness of the material used to make the microphone array independent of the ambient medium in which the microphone operates.

In rejecting claim 10, the Examiner admitted, on page 5, that Moorer and Elko both fail to teach an acoustically soft sphere. Instead, the Examiner relied on Staple as teaching "that the microphones are mounted on a soft sphere in order to reduce the vibration and noise." The Applicant submits that the Examiner mischaracterized the subject matter of claim 10 or the teachings of Staple or both in rejecting claim 10.

The Examiner does not cite what specific features taught in Staple constitute an example of the acoustically soft sphere of claim 10. Staple does teach the use of an elastomeric member 25 to reduce vibrations transmitted to the microphone transducer 10. See, e.g., Abstract, lines 9-11. Staple also teaches the use of vibration isolation member 32 to reduce vibrations transmitted to the microphone housing 12. See, e.g., Abstract, lines 13-15. Significantly, however, each of these members is acoustically hard when compared to the ambient air through which sound arrives at the microphone.

The Applicant submits that this provides additional reasons for the allowability of claim 10 as well as claims 40 and 61 (and claims 11, 41, and 62, which depend from claims 10, 40, and 61, respectively) over the cited references.

Claims 12, 42, and 63

According to claim 12, the number and positions of sensors in the microphone array enable representation of a beampattern as a series expansion involving at least second-order spheroidal harmonics.

As described previously, the only microphone array taught in Moorer whose number and positions of sensors enable representation of a beampattern as a series expansion of harmonics is the three-microphone array illustrated in Moorer's Fig. 8. Significantly, however, Moorer's three-microphone array is limited to first-order harmonics. Furthermore, the spatial harmonics taught in Moorer are cylindrical harmonics, not spheroidal harmonics. See, e.g., the cylindrical equations of column 10, lines 3-13. See also the fact that the three microphones in Fig. 8 lie in a plane. See also column 3, lines 27-31, which teaches that the speakers are all positioned in a single plane, as also represented in Fig. 1.

Elko teaches a microphone array whose number and positions of sensors enable representation of a beampattern as a series expansion of simple trigonometric functions that can be related to spheroidal harmonics, but those spheroidal harmonics are limited to first-order. There is no teaching or even suggestion in Elko for spheroidal harmonics of order greater than one.

Thus, Moorer alone and even the combination of Moorer and Elko fail to teach or even suggest that the number and positions of sensors in a microphone array enable representation of a beampattern as a series expansion involving at least second-order spheroidal harmonics. As such, the Applicant submits that this provides additional reasons for the allowability of claim 12 as well as claims 42 and 63 (and also claims 13, 43, and 64, which depend from claims 12, 42, and 63, respectively) over the cited references.

Claims 14, 44, and 65

According to claim 14, the arrangement of the sensors in the microphone array satisfies a discrete orthogonality condition. Note that claim 14 does not state that the eigenbeam outputs generated by the decomposition of claim 1 satisfy a discrete orthogonality condition. That may well be true, but what claim 14 recites is that it is "the arrangement of the sensors in the microphone array" that satisfies a discrete orthogonality condition.

In the present specification, Equation (53) provides an exemplary definition of the discrete orthogonality condition recited in claim 14. As explicitly defined in the specification, the discrete orthogonality condition of Equation (53) is a function of the number (S) and positions (ϑ_s, φ_s) of the sensors in the microphone array.

In rejecting claim 14, the Examiner completely failed to address the discrete orthogonality condition explicitly recited in claim 14.

The Applicant submits that Moorer does not teach or even suggest a microphone array whose arrangement of sensors satisfies a discrete orthogonality condition. In particular, the three-microphone array shown in Moorer's Fig. 8, as generally and specifically described, does not satisfy such a condition.

As such, the Applicant submits that this provides additional reasons for the allowability of claim 14 as well as claims 44 and 65 over Moorer.

Claims 15, 45, and 66

According to claim 15, decomposing the plurality of audio signals further comprises treating each sensor signal as a directional beam for relatively high frequency components in the audio signals. In rejecting claim 15, the Examiner stated that "Moorer shows the step of treating each sensor signal as a direction beam," citing column 7, lines 60-65. For the following reasons, the Applicant submits that the Examiner mischaracterized the teachings of Moorer in rejecting claim 15.

In column 7, lines 60-65, Moorer states:

> "Thus, in the representation of thiss algorithm shown as the matrix 51, the amplifiers 63, 67, 70, 73 and 76 have unity gain, the amplifiers 64, 68, 71, 74 and 77 have gains less than one that are cosine functions of the assumed speaker angles, and amplifiers 65, 69, 72, 75 and 78 have gains less than one that are sine functions of the assumed speaker angles."

The Applicant does not understand how these teachings in Moorer are in any way related to the feature explicitly recited in claim 15 that "decomposing the plurality of audio signals further comprises treating each sensor signal as a directional beam for relatively high frequency components in the audio signals." For example, the cited teachings in Moorer do not appear to have anything to do with high frequency components of audio signals. Nor do those teachings appear to have anything to do with treating each sensor signal as a directional beam.

As such, the Applicant submits that this provides additional reasons for the allowability of claim 15 as well as claims 45 and 66 over Moorer.

Claims 23 and 53

According to claim 23, an equalizer filter is applied to each eigenbeam output to compensate for frequency dependence of the corresponding eigenbeam. In rejecting claim 23, the Examiner stated that "Moorer shows the equalizer filter," citing column 6, lines 19-42. In response, the Applicant submits that the Examiner mischaracterized the teachings of Moorer in rejecting claim 23.

In column 6, Moorer describes the application of scalar weights. Such processing is not even filtering, let alone equalizer filtering. In fact, the terms "equalizer" and "filter" and their derivatives do not even appear in Moorer. As such, the Applicant submits that this provides additional reasons for the allowability of claim 23 and also claim 53 over Moorer.

Claim 26

According to claim 24, receiving the plurality of audio signals further comprises generating the plurality of audio signals using the microphone array. According to claim 25, which depends from claim 24, receiving the plurality of audio signals further comprises calibrating each sensor of the microphone array based on measured data generated by the sensor. According to claim 26, which depends from claim 25, receiving the plurality of audio signals comprises calibrating each sensor of the microphone array using a calibration module comprising a reference sensor and an acoustic source configured on an enclosure having an open side, wherein the open side of the volume is held on top of the sensor in order to calibrate the sensor relative to the reference sensor.

In rejecting claim 26, the Examiner admitted the "Moorer fails to show calibrating the microphones." Instead, the Examiner states that "Elko suggests calibrating the microphone to each other to improve the accuracy," citing column 17, lines 1-25.

While it is true that Elko teaches calibrating a microphone probe, Elko does not teach or even suggest all of the specific features recited in claim 26. For example, Elko does not teach or even suggest a calibration module comprising a reference sensor and an acoustic source configured on an enclosure having an open side, wherein the open side of the volume is held on top of the sensor in order to calibrate the sensor relative to the reference sensor. As such, the Applicant submits that this provides additional reasons for the allowability of claim 26 over the cited references.

Claims 27, 47, and 72

According to claim 27, the plurality of sensors are arranged in two or more concentric arrays of sensors, wherein each array is adapted for audio signals in a different frequency range. In rejecting claim 27 as being anticipated by Moorer, the Examiner completely failed to address the features explicitly recited in claim 27. In fact, the Applicant submits that Moorer does not teach or even suggest the specific features recited in claim 27. In particular, Moorer does not teach or even suggest a plurality of sensors are arranged in two or more concentric arrays of sensors, wherein each array is adapted for audio signals in a different frequency range. As such, the Applicant submits that this provides additional reasons for the allowability of claim 27 and similarly of claims 47 and 72 (and also claims 28, 48, and 73, which depends from claims 27, 47, and 72, respectively) over Moorer.

Claim 48

According to claim 48, the sensors in the different arrays are located at the same spherical coordinates. In rejecting claim 48 as being anticipated by Moorer, the Examiner completely failed to address the features explicitly recited in claim 48. In fact, the Applicant submits that Moorer does not teach or even suggest the specific features recited in claim 48. In particular, Moorer does not teach or even suggest that sensors in different arrays are located at the same spherical coordinates. As such, the Applicant submits that this provides additional reasons for the allowability of claim 48 over Moorer.

Claims 29, 49, and 74

According claim 29, all of the sensors are used to process relatively low-frequency signals, while only a subset of the sensors are used to process relatively high-frequency signals. In rejecting claim 29 as being anticipated by Moorer, the Examiner completely failed to address the features explicitly recited in claim 29. In fact, the Applicant submits that Moorer does not teach or even suggest the specific features recited in claim 29. In particular, Moorer does not teach or even suggest that all sensors are used to process relatively low-frequency signals, while only a subset of the sensors are used to process relatively high-frequency signals. As such, the Applicant submits that this provides additional reasons for the allowability of claim 29 and similarly of claims 49 and 74 (and also claims 30, 50, and 75, which depend from claims 29, 49, and 74, respectively) over Moorer.

Claims 30, 50, and 75

According to claim 30, only one of the sensors is used to process the relatively high-frequency signals. In rejecting claim 30 as being anticipated by Moorer, the Examiner completely failed to address the features explicitly recited in claim 30. In fact, the Applicant submits that Moorer does not teach or even suggest the specific features recited in claim 30. In particular, Moorer does not teach or even suggest that only one of the sensors is used to process the relatively high-frequency signals. As such, the Applicant submits that this provides additional reasons for the allowability of claim 30 and similarly of claims 50 and 75 over Moorer.

New Claims 76-78

According to claim 16, an auditory scene is generated based on the eigenbeam outputs and their corresponding eigenbeams. According to new claim 76, which depends from claim 16, the auditory scene is a second-order or higher directional beam steered in a specified direction, and generating the auditory scene comprises (1) receiving the specified direction for the directional beam and (2) generating the directional beam by combining the eigenbeam outputs based on the specified direction. New claims 77-78 recites similar features. Support for new claims 76-78 is found, for example, on page 5, lines 29-31, of the specification.

Moorer teaches a technique for generating a desired sound field using a specific configuration of speakers. Moorer does not teach or even suggest a technique for generating a second-order or higher directional beam steered in a specified direction. Elko also does not teach or even suggest a technique for generating a second-order or higher directional beam steered in a specified direction.

As such, the Applicant submits that this provides additional reasons for the allowability of claim 76 as well as claims 77-78 over the cited references.

For the reasons set forth above, the Applicant respectfully submits that the rejections of claims 1-75 under Sections 102(b) and 103(a) have been overcome. Furthermore, new claims 76-78 patentably define over the cited references.

In view of the above amendments and remarks, the Applicant believes that the now-pending claims are in condition for allowance. Therefore, the Applicant believes that the entire application is now in condition for allowance, and early and favorable action is respectfully solicited.

Respectfully submitted,

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